ARKIV FÖR FYSIK Band 12 nr 21

Communicated 22 May 1957 by Erik Hulthén

Flame spectra of metal compounds in the infra-red

By Albin Lagerqvist and Lennart Huldt

With 6 figures in the text

Not very much work has been done on the spectra of metal compounds in the infra-red region. This paper, which we consider a preliminary work, gives some results on flame-spectra of certain metals, investigated from about 1 μ up to about 15 μ. The emission spectra obtained probably emanate from the metal oxides.

As a source of light, we have used a Lundegårdh-air-acetylene flame fed with a solution containing a metal salt (usually the chloride). The spectrograph used was a Perkin Elmer mod. 13 spectrophotometer, supplied with a rock salt prism and of focal length of 27 cm. Spectra were recorded by a Leeds and Northrup Speedomax recorder. Unfortunately the flame also emits strong H_2O and CO_2 bands, which are partly absorbed by the air. The presence of these bands makes the discovery of other spectra very difficult in certain parts of the spectrum. No token of emission has been found for any of the salts investigated for wavelengths greater than 3.6 μ.

We also tried to find the vibrational transition 1–0 of the lowest known $^1\Sigma$ state of BaO. The values for the dissociation energy of BaO obtained by different methods (spectroscopic method [1], thermodynamic methods [2, 3] mass spectrometric method [4], flame method [5, 6] are in good agreement with each other. From this it follows that it is very likely that the lowest known $^1\Sigma$ state of BaO is the ground state. The vibrational transition 1–0 ought to lie at 15.0 μ (666 cm^{-1}). We could not, however, find this band. This negative result does not mean that the band does not exist. The transition probability is very much smaller for a vibrational transition than for an electronic transition, and therefore the band is expected to be very weak.

Other metals investigated were Cu, La, Ti, V, Cr, Mn, Fe, Co, and Ni. No emission was obtained from Cu, Co and Ni. The salts used were $CuCl_2$, $CoSO_4$, and $NiCl_2$.

For La, a $LaCl_3$ solution was used. No new bands were found. Fig. 1 shows the $A^2\Pi$–$X^2\Pi$ band-system of LaO [7, 8]. Several band-systems attributed to TiO are obtained in the arc up to 11240 Å [9]. Fig. 2 shows the traces from the flame fed by $TiCl_3$. This figure, like every subsequent one, also contains a record of the pure flame spectrum obtained under similar conditions. Several identical runs were performed for each spectrum in order to eliminate possible fluctuations in the flame emission. In Fig. 2 the emission originating from the titanium can be seen up to 2.4 μ.

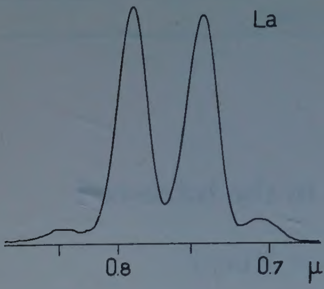

Fig. 1. Flame spectrum of LaO.

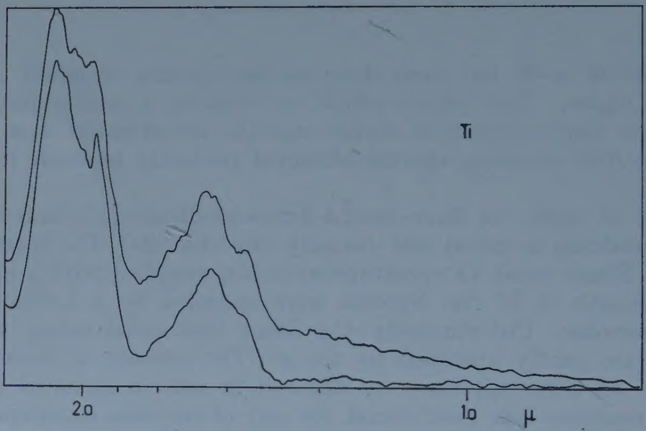

Fig. 2. Spectrum of the flame, fed with $TiCl_3$. The lower curve represents pure flame.

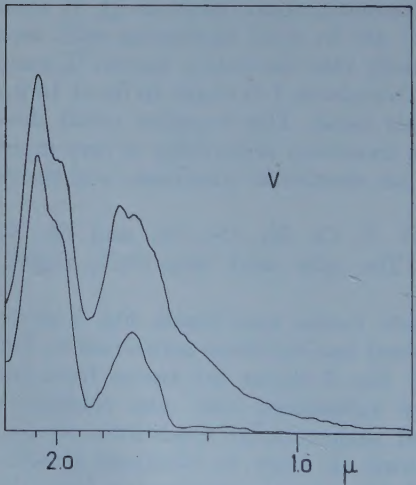

Fig. 3. Spectrum of VCl_3-fed flame and of pure flame.

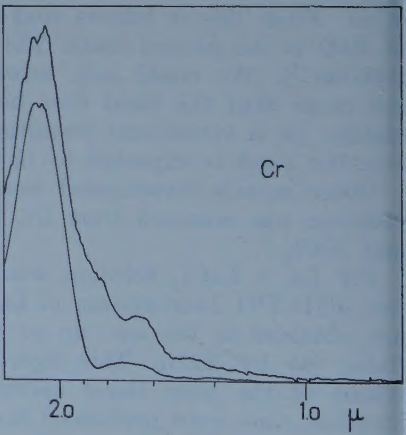

Fig. 4. Spectrum of $CrCl_3$-fed flame and of pure flame.

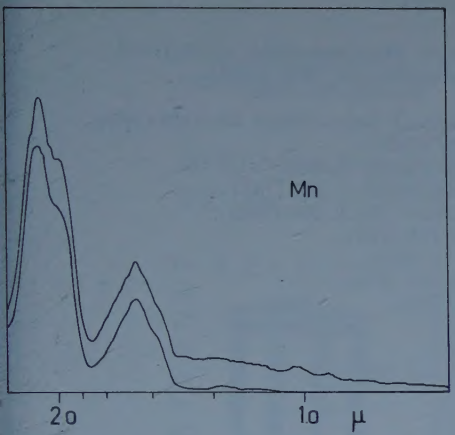

Fig. 5. Spectrum $MnCl_2$-fed of flame and of pure flame.

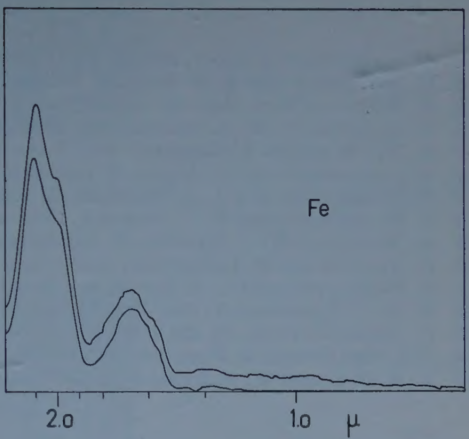

Fig. 6. Spectrum of $FeCl_3$-fed flame and of pure flame.

By means of a spectrograph of low resolving power, Kleman and Liljeqvist [10] found that salts of vanadium and chromium give strong emission from a flame in the near infra-red region (up to 1.6 μ). Our result with VCl_3 confirms this, and furthermore shows emission up to 2.4 μ, as is seen from Fig. 3, and traces at even longer waves. Infra-red bands of VO emitted from an arc are known up to about 10600 Å [11].

The flame fed with $CrCl_3$ shows a very strong emission below 2.4 μ (Fig. 4). Earlier, CrO bands are known up to about 8400 Å [12, 13].

The run with $MnCl_2$ also gave a positive result (Fig. 5). Previosly, MnO bands were known up to 6700 Å [14].

Finally the traces obtained with $FeCl_3$ are shown in Fig. 6. A strong emission is present up to 2.4 μ. At longer wave-lengths a very faint emission could be discerned. FeO bands were formerly known up to 1.4 μ [15].

We wish to emphasize strongly that, with the method used here, it is only possible to investigate very roughly emission from addends to the flame. The low resolving power of the instrument used does not permit analysis of the spectra obtained. Further, it is of course difficult to decide the identity of the emitters. The most probable postulate seems to be, however, that the spectra are emitted by the oxides. Our records show that with great probability a good deal of information ought to be obtained for several molecules through extended investigations of the infra-red spectra.

Physics Department, University of Stockholm and
Institute of Optical Research, Royal Institute of Technology, Stockholm 70,
May, 1957.

REFERENCES

1. A. Lagerqvist, E. Lind, and R. F. Barrow, Proc. Phys. Soc. *53 A*, 1132 (1950).
2. G. Drummond and R. F. Barrow, Trans. Faraday Soc. *47*, 1275 (1951).
3. L. Brewer, Chem. Rev. *52*, 1 (1953).
4. M. G. Inghram, W. A. Chupka, and R. F. Porter, J. Chem. Phys. *23*, 2159 (1955).
5. L. Huldt and A. Lagerqvist, Ark. f. fys. *2*, 333 (1950).
6. A. Lagerqvist and L. Huldt, Z. f. Naturforsch. *9 a*, 991 (1954).
7. W. F. Meggers and J. A. Wheeler, J. Res. Bur. Stand. *6*, 239 (1931).
8. L. W. Johnson and R. C. Johnson, Proc. Roy. Soc. *133 A*, 207 (1931).
9. K. Wurm and H. J. Meister, Z. Astrophys. *13*, 199 (1937).
10. B. Kleman and B. Liljeqvist, Ark. f. fys. *9*, 377 (1955).
11. A. Lagerqvist and L. E. Selin, Ark. f. fys. *11*, 429 (1957).
12. W. F. C. Ferguson, J. Res. Bur. Stand. *8*, 381 (1932).
13. C. Ghosh, Z. Phys. *78*, 521 (1932).
14. A.K. Sen Gupta, Z. Phys. *91*, 471 (1934).
15. A. M. Bass and W. S. Benedict, Astrophys. J. *116*, 652 (1952).

Tryckt den 30 augusti 1957

Uppsala 1957. Almqvist & Wiksells Boktryckeri AB